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ISSN: 2277-9655
[Manikandan * *et al.*, 6(9): September, 2017] Impact Factor: 4.116
IC™ Value: 3.00 CODEN: IJESS7

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

A LITERATURE SURVEY OF EXISTING MAP MATCHING ALGORITHM FOR NAVIGATION TECHNOLOGY

Mr. R. Manikandan[*1] & Dr.R.Latha[2]
[*1]Research Scholar, Computer Applications, St.Peter's University, Chennai.
[2]Prof & Head., Dept of Computer Applications, St.Peter's University, Chennai

DOI: 10.5281/zenodo.891980

ABSTRACT
Map Matching Algorithm plays vital role in today navigation technology, especially in the Urban Area. This Paper deals with a feasibility study of Map Matching algorithm to implement various processes in the Urban Areas. The main objectives of this paper are to gather knowledge about recent trends in Navigation System using Map Matching Algorithm. Map Matching Algorithm is mainly used to control and monitor the vehicle in the Urban Areas which may leads avoid traffic, accidents and also reduce the time taken from one place to another place. The eight based processes of Map Matching algorithm are a) weight based b) Enhanced Based c) Enhanced, Weight Based d) Fuzzy Based e) Hidden Markov Based f) Activity of Edge Based g) Distributed Based and h) Offline Based. We mainly classified process of Map Matching algorithm as feasibility study, which is mainly implemented in the Urban Cities

I. INTRODUCTION
Map Matching algorithm which is used to Map the Physical Location using GPS. An Algorithm which is used to find the exact location of vehicle or particular position of an object is called Map Matching algorithm. Map Matching algorithm are divided into two categories: one is offline where the data are processed after the data are recorded and other is online, where the data are processed during recording time. Map-matching algorithm is actually a pattern identification process, a number of map-matching algorithms have been developed, these algorithms include Kalman filter, fuzzy logic and belief theory [1] etc. In general, map-matching algorithms can be categorized into four groups: geometric, topological, probabilistic and other advanced techniques. The geometric map-matching algorithm was introduced by Bernstein and Kornhauser [2] first. This algorithm contains point-to-point matching, point-to-curve matching, and curve-to-curve matching and improved geometric map matching [2]. Point-to-point and point-to-curve matching don't fully make use of historical information, while curve-to-curve matching constructs piecewise linear curves from the paths that originate from the candidate nodes. Whereas it is quite sensitive to outliers and depends on point-to-point matching in result of sometimes yielding unexpected and undesirable results [1].

II. PROCESS OF POSITIONING IN MAP MATCHING ALGORITHM
Process of Map Matching Algorithm can be classified into three categories to find out the position of particular object or vehicle. Macro scale: Navigation usually performs the task of finding a particular path between two nodes in the network consisting of link. Micro scale: Typically consider navigation at the vehicle and is concerned with task such as lane keeping as well as detecting and avoiding obstacles.Mesoscale: which is a level in between micro scale and macro scale, consider vehicle operation at link level. Form a Navigation point of view, mesoscale route planning is generally concerned with vehicle such as passing, pulling off the side of the roadway, moving out of the way of emergency vehicle, merging in and out special.

III. EXISTING MAP MATCHING ALGORITHM

A. Weight Based Map Matching Algorithm
A map-matching algorithm is an integral part of every navigation system usually from a global positioning system [GPS] with digital road network data. Since both performances (speed) and accuracy are equally important in real-time map-matching, an accurate and efficient map-matching algorithm.

ISSN: 2277-9655
Impact Factor: 4.116
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This algorithm has three steps: initialization, same-segment, and next-segment. Distance between the GPS point and road segments, difference between the heading of the GPS point and direction of road segments [3]. The difference between the direction of consecutive GPS points and direction of road segments are used to identify the best segment among candidates near intersections. The weight of each criterion in this algorithm is dynamic.

The weights of criteria are calculated for each GPS point based on its: (a) positional accuracy, (b) speed, and (c) traveled distance from previous GPS point. The algorithm considers a confidence level on the assigned segment to each GPS point, which is calculated based on the density and complexity of roads around the GPS point. The evaluation results indicate 95.34% correct segment identification and 92.19% correct segment assignment. The most important feature of our algorithm is that the high correct segment identification percentage achieved in urban areas is through a simple and efficient weight-based method that does not depend on any additional data or positioning sensors other than digital road network and GPS.

B. Enhanced Map Matching Algorithm

In dense urban areas it is still difficult to obtain good positioning using a single technology. This problem has led to the introduction of combining multiple positioning techniques. Intelligent Urban Positioning (IUP) is based on combining positioning algorithms augmented with three dimensional mapping techniques for distinguishing between non-line-of-sight (NLOS) and line-of-sight (LOS) signals and multi-constellation GNSS, using signals from all visible satellites. This can be used to predict the blockage and reflection of signals [5]. For example, a method using a 3D city model to improve cross-street GNSS positioning accuracy.

Additionally, digital map shave improved their accuracy, mainly when their construction methods have changed from air pictures to instrumented vehicles. The use of instrumented vehicles usually includes satellite positioning systems and inertial systems and both measurements are combined [4]. Although both sources are combined, their own particular errors mean the final map is not perfectly accurate.

Furthermore, it must be taken into account that optimized storage of spatial road network data involves simplifications that can be larger or smaller according to the kind of approximation employed. Finally, as stated in [6], "the process of continually estimating a user's position on a road segment is known as map matching".

In this process, it has to be taken into account that both information sources (GNSS positioning and digital map data) have associated errors, and therefore the algorithm attempts to found the location of the vehicle on the link that most approaches its real position.

C. Enhanced Weight Map Matching Algorithm

Current MM algorithms categorize the whole metropolis area as urban, suburban and rural area. In the urban area of a metropolis road network is quite intricate and its density performs various, and most existing MM algorithms barely consider this. Therefore, to develop an enhanced weight-based MM algorithm in order to involve this situation and assess its performance using real-world field data.

This process includes:[7] the classification of urban area by urban road density, the derivation of four weights(including heading, proximity, link connectivity and turn restriction) in different areas through an optimization process, the different performances of the algorithm before and after enhancement using a real positioning data set.

The whole process is divided into three key stages:

a) Initial MM,
b) MM on a link and
c) MM at a junction.

Process (a):
Step 1: Identify a set of the candidate links
Step 2: Identify the correct link from the set of the candidate links
Step 3: Determinate vehicle position on the identified link
Step 4: If the vehicle speed is 0, go to Process (b) Step 1.
Step 5: If the next positioning fix is not near to a junction, go to

Process (b) Step 1. Otherwise, go to Process (c) Step 3.
Process (b):
Step 1: Choose the previously selected link as the correct link.
Step 2: Determinate vehicle position on the identified link.
Step 3: Go to Process (a) Step 1.

Process (c):
Step 4: Go to Process (a) Step 1.

The enhanced MM algorithm has the potential to be applied in a range ITS services with a low polling frequency positioning data. This enhanced MM algorithm is fast, simple and very efficient and therefore, has the good potential to be implemented by industry, especially in city with intricate road network.

D. Fuzzy Based Map Matching Algorithm

The algorithm is described as follows:

1. Acquiring the GPS positioning data including the location and the heading.
2. Using rectangle error region instead of error ellipse region.
3. Determining the current grid through the grid index.
4. Filtering the candidate road sections according to the rectangle error region.
5. Calculating the membership degree for each two candidate sections according to the matching function.
6. Sorting adaptive fuzzy according to the membership degree of all candidate road section.
7. Selecting the candidate with the maximum membership as the matching road section.
8. Calculating projection from the GPS position located directly to the matching road section, which means the projection point is the matching point.

The algorithm compares the road membership value of candidates by fuzzy sorting, and adjusts the measure coefficient to improve the accuracy of map matching.

E. Hidden Markov Method Based Map Matching Algorithm

Hidden Markov Model (HMM) is a Markov process comprising a number of hidden (unobserved) states. Transitions between states can occur with a certain probabilities. Each state is assigned with a set of observations. One of them is to be output, as the state is reached. For a given state conditional probabilities of observations occurrence (emission probabilities) sum up to 1. A problem that can be elegantly formulated with HMM is the decoding problem: it consists in finding the most probable sequence of transitions between hidden states that would produce a given sequence of observations. Such sequence can be efficiently determined with the well-known Viterbi algorithm.

There are at least four implementations of global map-matching algorithms [9-12] that employ HMM approach. In all of them hidden states correspond to projections of vehicle positions on road segments and observation to location data obtained mainly from GPS sensors. Transition probabilities are established based on links connectivity and/or dead reckoning, whereas emission probabilities assume Gaussian distribution of GPS noise.

The main difference that should be emphasized is that our algorithm is incremental, i.e. it does not build a single HMM model for a given GPS trace to be analyzed afterwards with the Vitrebi algorithm, but updates the HMM model on each input and in some situations only applies the Viterbi algorithms. Moreover, the algorithms can be a basis for developing real-time services like vehicle tracking and track estimation.

F. AOE Based Map Matching Algorithm

The Existing map-matching algorithms are not suitable for the low-frequency FCD (floating car data). By analyzing local map-matching algorithms and global map-matching algorithms, and overall considering the FCD trace, a map-matching algorithm for low-frequency FCD based on improved AOE (activity on edge) network was proposed.

Firstly, intersection analysis between a buffer around a GPS point and road segments was carried out to acquire the candidate road segments and candidate map-matching points. Secondly, quad tree spatial index and Dijkstra algorithm were introduced to obtain the shortest path between the adjacent candidate map matching points.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

Thirdly, the improved AOE network was built to search the FCD shortest path and the map-matching points were acquired. Lastly, the proposed algorithm was evaluated in terms of time efficiency and accuracy.

Results show that the accuracy of the proposed algorithm is 95.3%, and the total program execution time is 96.8 s. The accuracy is respectively 13.6% and 2.8% higher than that of the local map-matching algorithm and global map-matching algorithm

G. Distributed Map Matching Algorithm

The main idea is to reduce the algorithm running time by distributing the processing across multiple working nodes.

Distributed Map Matching Algorithm Concepts:

1. A trajectory point is a quadruple consisting of id, time stamp, latitude and longitude.
2. A trajectory is a duple consisting of id and a sequence of trajectory points where, for each trajectory point pi, tpi < tpi+1 (where tpi is the time stamp of pi).
3. A graph is a data structure composed of vertices and edges. An edge is a triple consisting of source vertex id, target vertex id and attributes. A vertex is a duple consisting of id and attributes [15], [16].
4. A k-d tree [17] is a binary search tree where each node is a k-dimensional point [18], useful for nearest neighbor searches.

Each trajectory point is a position that must be mapped to a corresponding point in the road network. Considering GPS precision errors, the nearest point is not necessarily the correct one.

Therefore, the whole trajectory must be considered to avoid potentially wrong matching. So, instead of mapping each point to its nearest node in a digital map (a method known as point by point matching), a set of possible paths is maintained and the most likely path is chosen based on probability. This is called a multiple hypothesis technique (MTH) and it is used in some map-matching strategies [19].

H. Offline Based Map Matching Algorithm

Map-Matching algorithms are used to fix location data into a spatial road network. They are used in the most varied applications. The most common ones are certainly the GPS car navigation devices, which are constantly indicating the road segment where the user is located based on information retrieved from GPS satellites. The purpose of a Map-Matching algorithm can be divided in two parts. Firstly, the algorithm determines which road segment, from a given network, corresponds to each given position. Afterwards, it will determine the exact location of the same position inside the segment previously selected [21, 22].

There are algorithms designed specifically for given applications and others that are generic. In some situations, the path is known in advance so the set of roads to perform the matching is restricted to them. For instance, the match of bus location data can be improved by restricting the road network to the known path taken [22]. Generic algorithms can also be one of two types: online or offline [21]. Real-time applications, such as GPS navigation devices use online algorithms, meaning that the matching is performed as the data is being received and thus it is based only on past matches.

Offline algorithms can take the advantage of not only matching each point according to past data but also based on the following “future” point, which helps the algorithm to select the correct road near to junctions. The literature review made by [21] states that the majority of the existent algorithms are for real-time applications, since the demand here is higher than in post-processing ones. In fact, only one offline algorithm is presented [23].

These algorithms use, as input, GPS coordinates to perform the matching, but most of them consider using an integration of GPS data with Dead-Reckoning (DR) in order to improve the matching accuracy [24]. DR systems use some sensors like odometers and gyroscopes in order to calculate subsequent positions in relation to the initial one. In these systems, the probability of the estimated position being wrong increases exponentially as more readings are made, since the new position given is calculated based on the previous one and on the readings from sensors that might have errors as well [24]. In [21], the author classifies Map-Matching algorithms into four groups, depending on the techniques applied by each one to perform the match. They are: geometric, topological, probabilistic and other advanced algorithms.

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IV. CONCLUSION

We conclude that, each process of Map Matching algorithm has its own identity. Simplification of each identity is as follows. Weight Based –Segmentation identification, Enhanced Based-Narrow Street and Tall building, Enhanced Weight Based-low pooling frequency data, Fuzzy-Region determination, Hidden Markov-Expansion and Contraction, Activity on Edge based-Low Frequency Car Data, Distributed Map-High Accuracy and Scalability for Trajectory points and offline based-Reliable and Robustness. Each process has its own pros and cons. These processes mainly focus on Time Efficiency and accuracy of map matching algorithms in the URBAN Areas.

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CITE AN ARTICLE

Manikandan, R., Mr, & Latha, R., Dr. (2017). A LITERATURE SURVEY OF EXISTING MAP MATCHING ALGORITHM FOR NAVIGATION TECHNOLOGY. *INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY*, *6*(9), 326-331. Retrieved September 15, 2017.